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Terrazas et al.

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(54) **METHODS AND APPARATUS TO ESTIMATE DEMOGRAPHY BASED ON AERIAL IMAGES**

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(52) **U.S. Cl.**
CPC ***G06K 9/0063*** (2013.01); ***G06K 9/00637*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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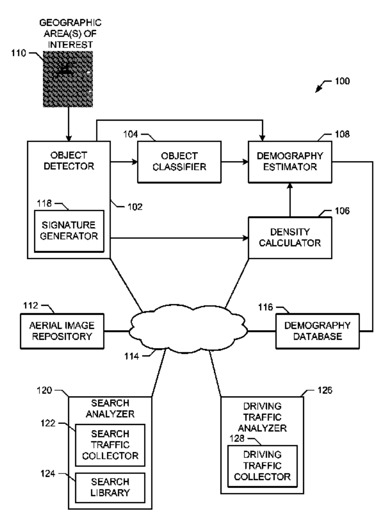
(57) **ABSTRACT**

Methods and apparatus to estimate demography based on aerial images are disclosed. An example method includes analyzing a first aerial image of a first geographic area to detect a first plurality of objects, and estimating a demographic characteristic of the first geographic area based on the first plurality of objects.

25 Claims, 10 Drawing Sheets



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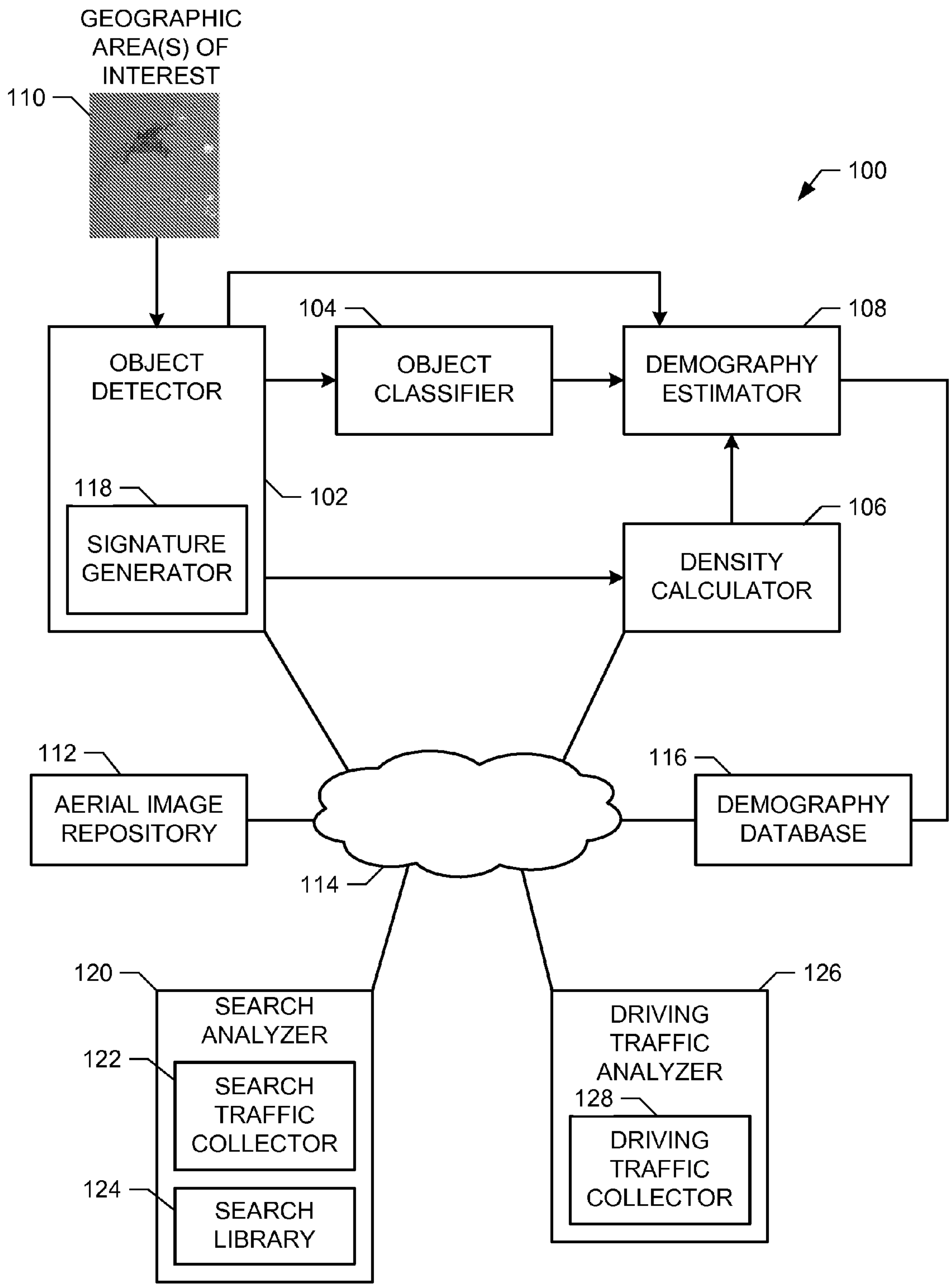
GEOGRAPHIC AREA(S) OF INTEREST
110
100
104
108
OBJECT DETECTOR
OBJECT CLASSIFIER
DEMOGRAPHY ESTIMATOR
118
102
106
SIGNATURE GENERATOR
DENSITY CALCULATOR
112
116
AERIAL IMAGE REPOSITORY
DEMOGRAPHY DATABASE
114
120
126
SEARCH ANALYZER
DRIVING TRAFFIC ANALYZER
122
SEARCH TRAFFIC COLLECTOR
128
DRIVING TRAFFIC COLLECTOR
124
SEARCH LIBRARY

FIG. 1

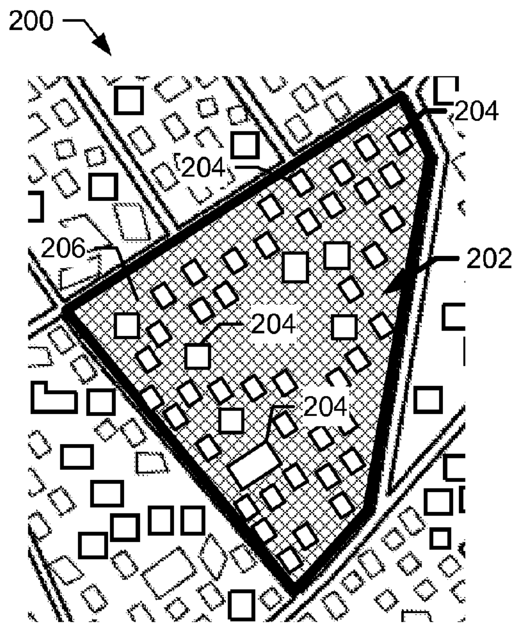

FIG. 2

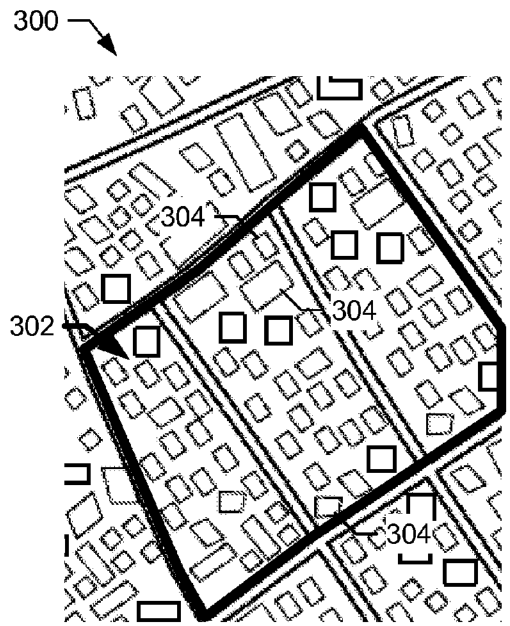

FIG. 3

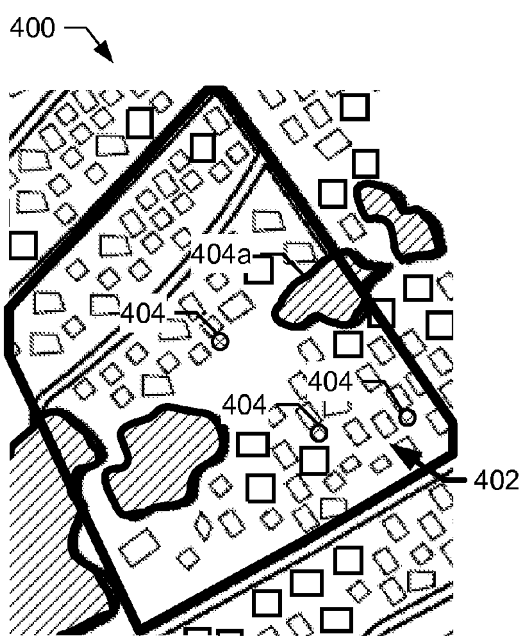

FIG. 4

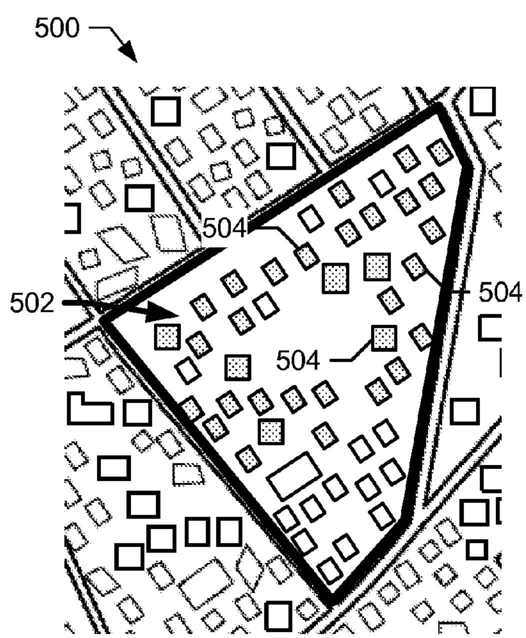

FIG. 5

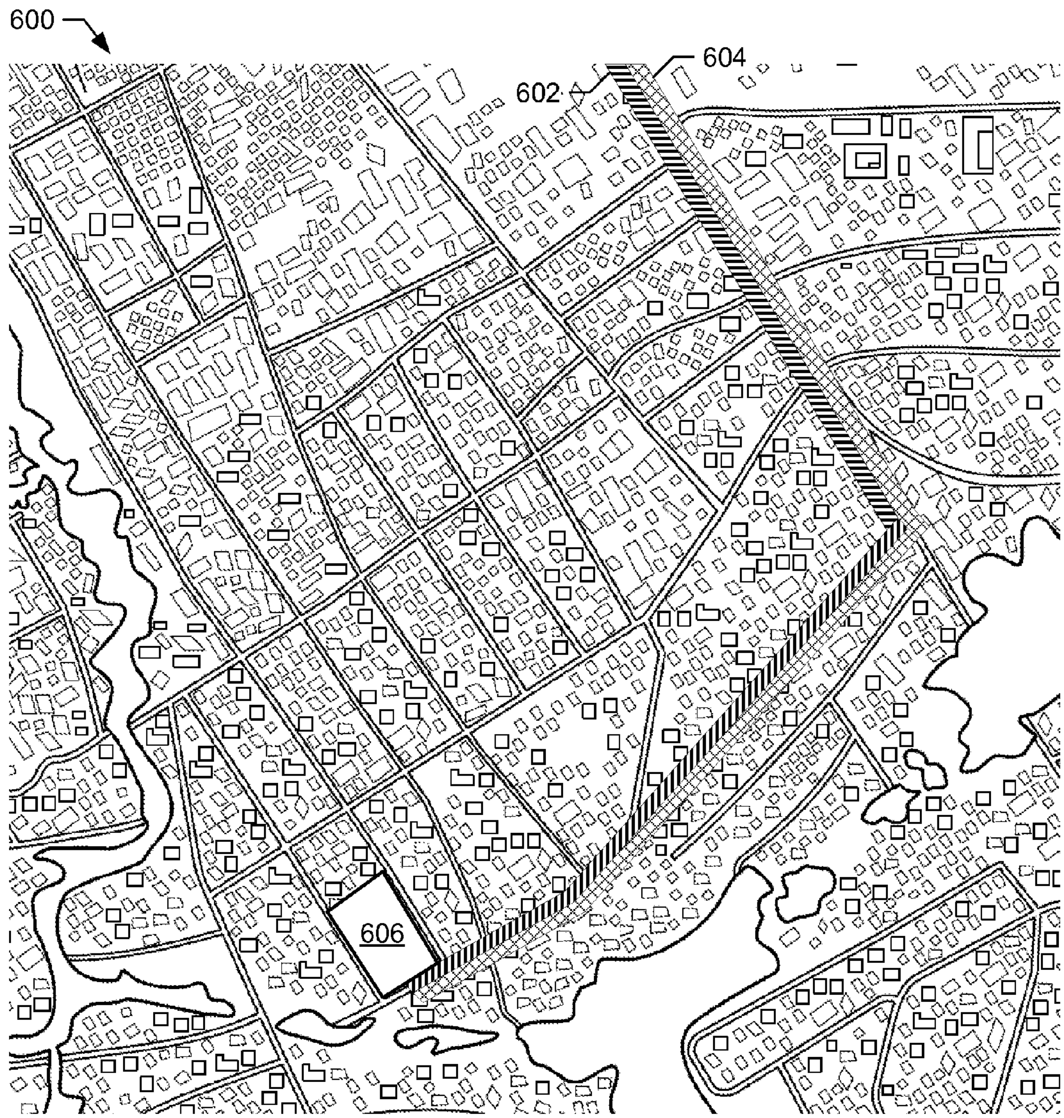

FIG. 6

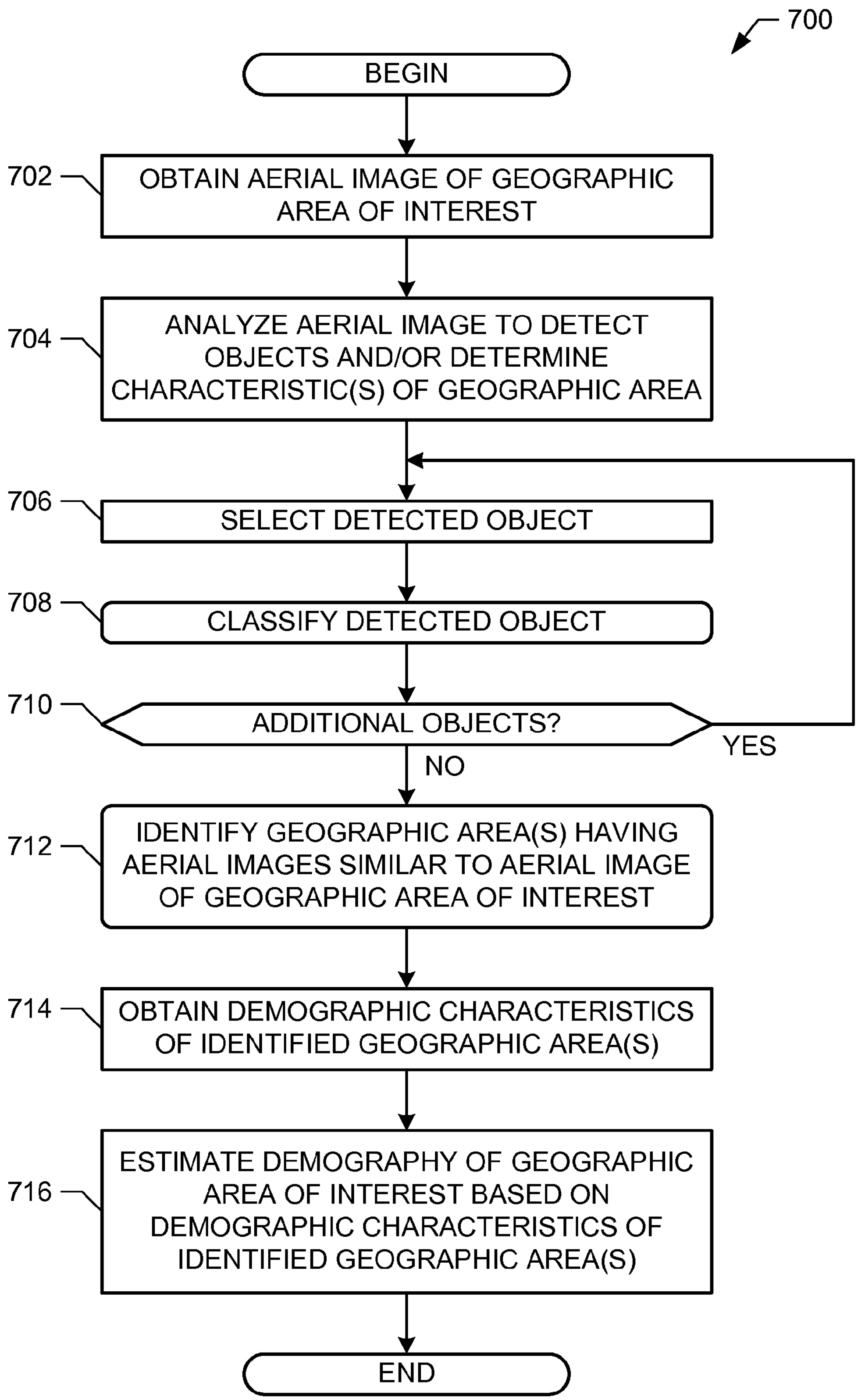
700
BEGIN
702
OBTAIN AERIAL IMAGE OF GEOGRAPHIC AREA OF INTEREST
704
ANALYZE AERIAL IMAGE TO DETECT OBJECTS AND/OR DETERMINE CHARACTERISTIC(S) OF GEOGRAPHIC AREA
706
SELECT DETECTED OBJECT
708
CLASSIFY DETECTED OBJECT
710
ADDITIONAL OBJECTS?
YES
NO
712
IDENTIFY GEOGRAPHIC AREA(S) HAVING AERIAL IMAGES SIMILAR TO AERIAL IMAGE OF GEOGRAPHIC AREA OF INTEREST
714
OBTAIN DEMOGRAPHIC CHARACTERISTICS OF IDENTIFIED GEOGRAPHIC AREA(S)
716
ESTIMATE DEMOGRAPHY OF GEOGRAPHIC AREA OF INTEREST BASED ON DEMOGRAPHIC CHARACTERISTICS OF IDENTIFIED GEOGRAPHIC AREA(S)
END

FIG. 7

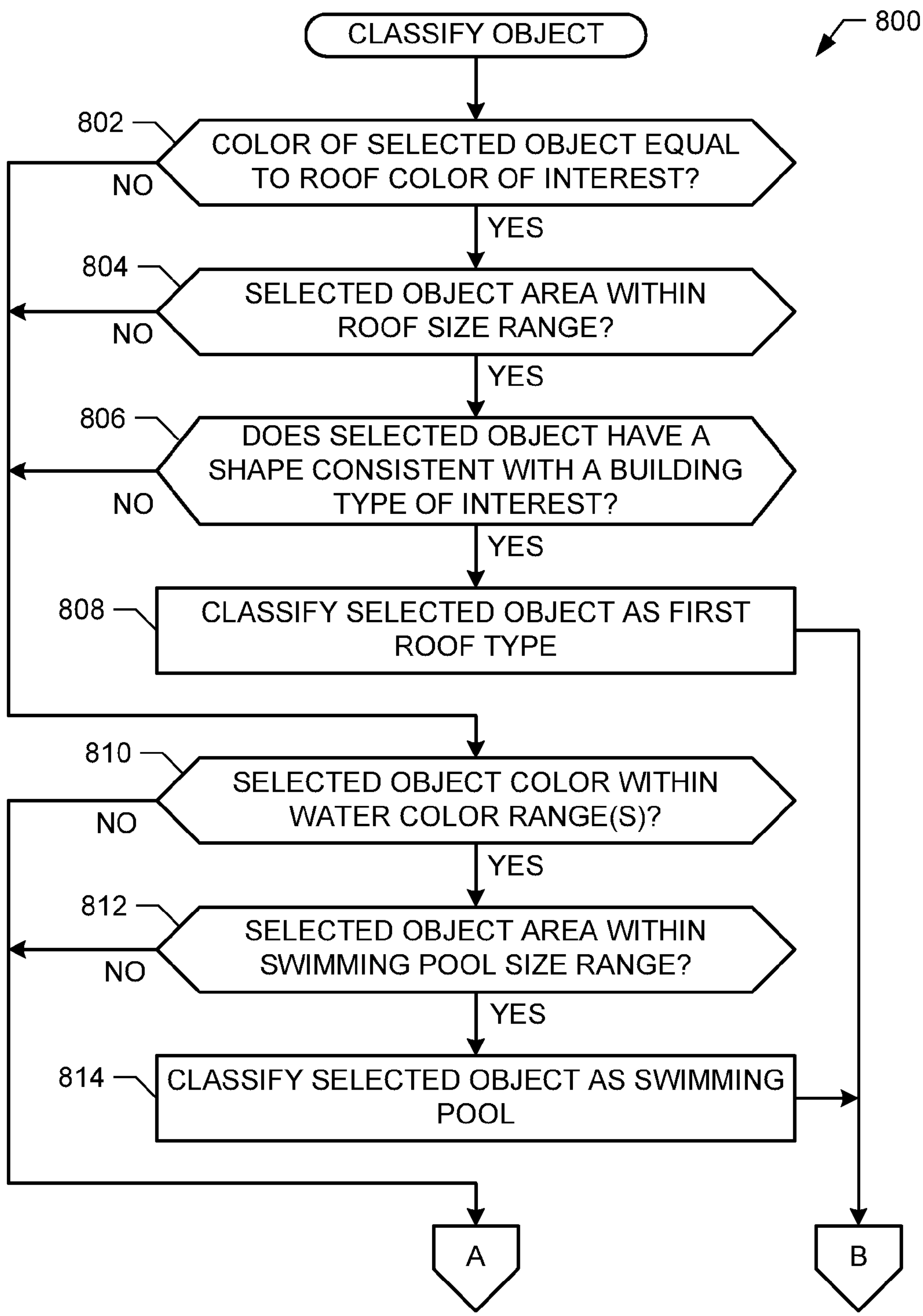
800
CLASSIFY OBJECT
802
COLOR OF SELECTED OBJECT EQUAL TO ROOF COLOR OF INTEREST?
NO
YES
804
SELECTED OBJECT AREA WITHIN ROOF SIZE RANGE?
NO
YES
806
DOES SELECTED OBJECT HAVE A SHAPE CONSISTENT WITH A BUILDING TYPE OF INTEREST?
NO
YES
808
CLASSIFY SELECTED OBJECT AS FIRST ROOF TYPE
810
SELECTED OBJECT COLOR WITHIN WATER COLOR RANGE(S)?
NO
YES
812
SELECTED OBJECT AREA WITHIN SWIMMING POOL SIZE RANGE?
NO
YES
814
CLASSIFY SELECTED OBJECT AS SWIMMING POOL
A
B

FIG. 8A

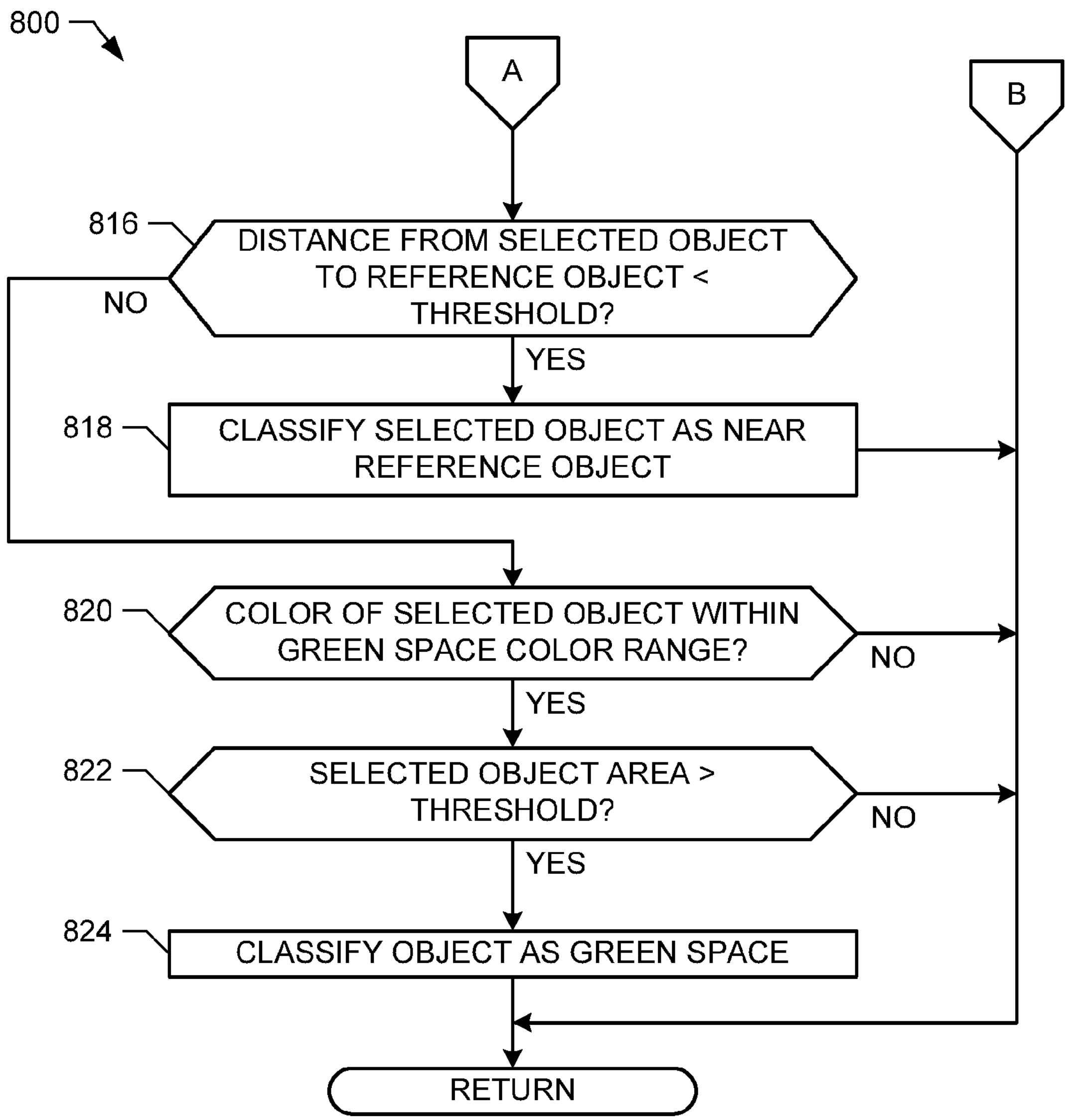
800
A
B
816
DISTANCE FROM SELECTED OBJECT TO REFERENCE OBJECT < THRESHOLD?
NO
YES
818
CLASSIFY SELECTED OBJECT AS NEAR REFERENCE OBJECT
820
COLOR OF SELECTED OBJECT WITHIN GREEN SPACE COLOR RANGE?
NO
YES
822
SELECTED OBJECT AREA > THRESHOLD?
NO
YES
824
CLASSIFY OBJECT AS GREEN SPACE
RETURN

FIG. 8B

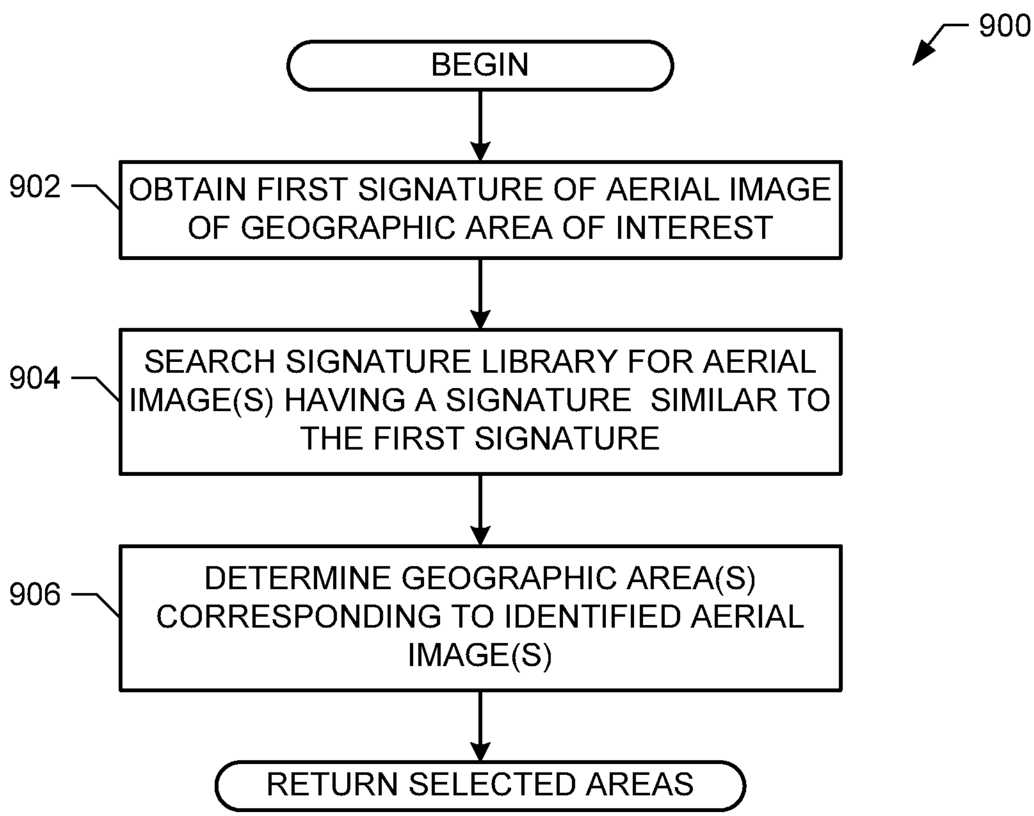
900
BEGIN
902
OBTAIN FIRST SIGNATURE OF AERIAL IMAGE OF GEOGRAPHIC AREA OF INTEREST
904
SEARCH SIGNATURE LIBRARY FOR AERIAL IMAGE(S) HAVING A SIGNATURE SIMILAR TO THE FIRST SIGNATURE
906
DETERMINE GEOGRAPHIC AREA(S) CORRESPONDING TO IDENTIFIED AERIAL IMAGE(S)
RETURN SELECTED AREAS

FIG. 9

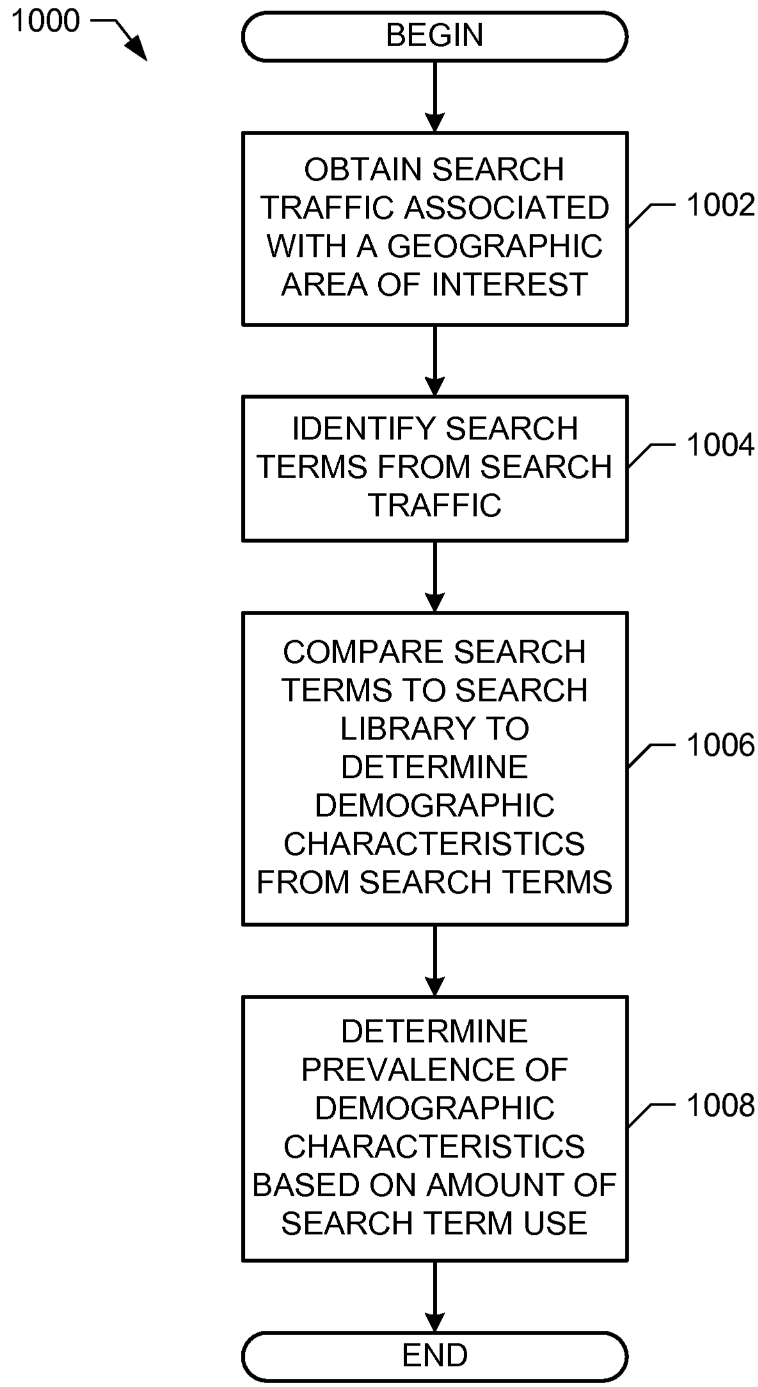
1000
BEGIN
OBTAIN SEARCH TRAFFIC ASSOCIATED WITH A GEOGRAPHIC AREA OF INTEREST
1002
IDENTIFY SEARCH TERMS FROM SEARCH TRAFFIC
1004
COMPARE SEARCH TERMS TO SEARCH LIBRARY TO DETERMINE DEMOGRAPHIC CHARACTERISTICS FROM SEARCH TERMS
1006
DETERMINE PREVALENCE OF DEMOGRAPHIC CHARACTERISTICS BASED ON AMOUNT OF SEARCH TERM USE
1008
END

FIG. 10

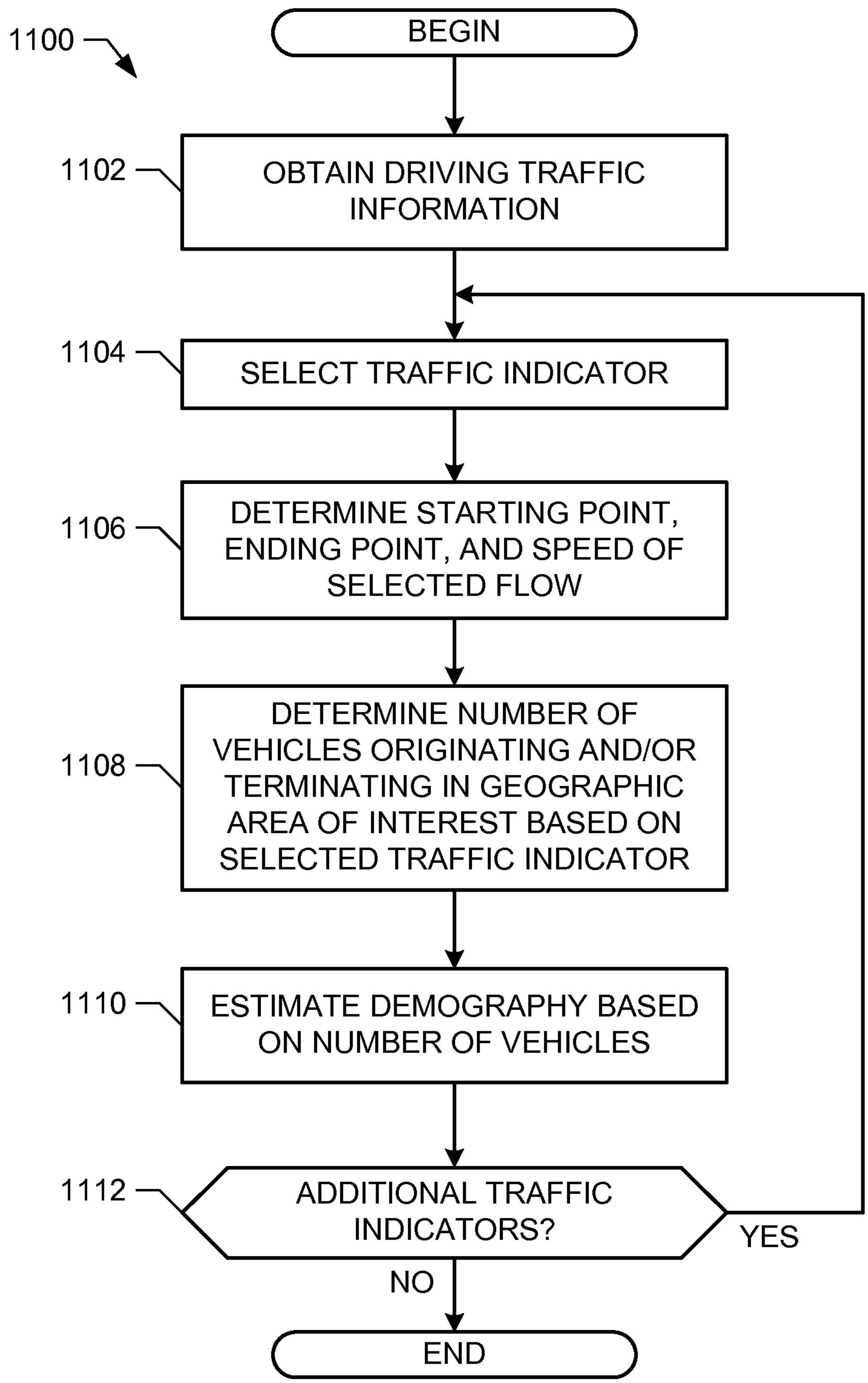
1100
BEGIN
1102
OBTAIN DRIVING TRAFFIC INFORMATION
1104
SELECT TRAFFIC INDICATOR
1106
DETERMINE STARTING POINT, ENDING POINT, AND SPEED OF SELECTED FLOW
1108
DETERMINE NUMBER OF VEHICLES ORIGINATING AND/OR TERMINATING IN GEOGRAPHIC AREA OF INTEREST BASED ON SELECTED TRAFFIC INDICATOR
1110
ESTIMATE DEMOGRAPHY BASED ON NUMBER OF VEHICLES
1112
ADDITIONAL TRAFFIC INDICATORS?
YES
NO
END

FIG. 11

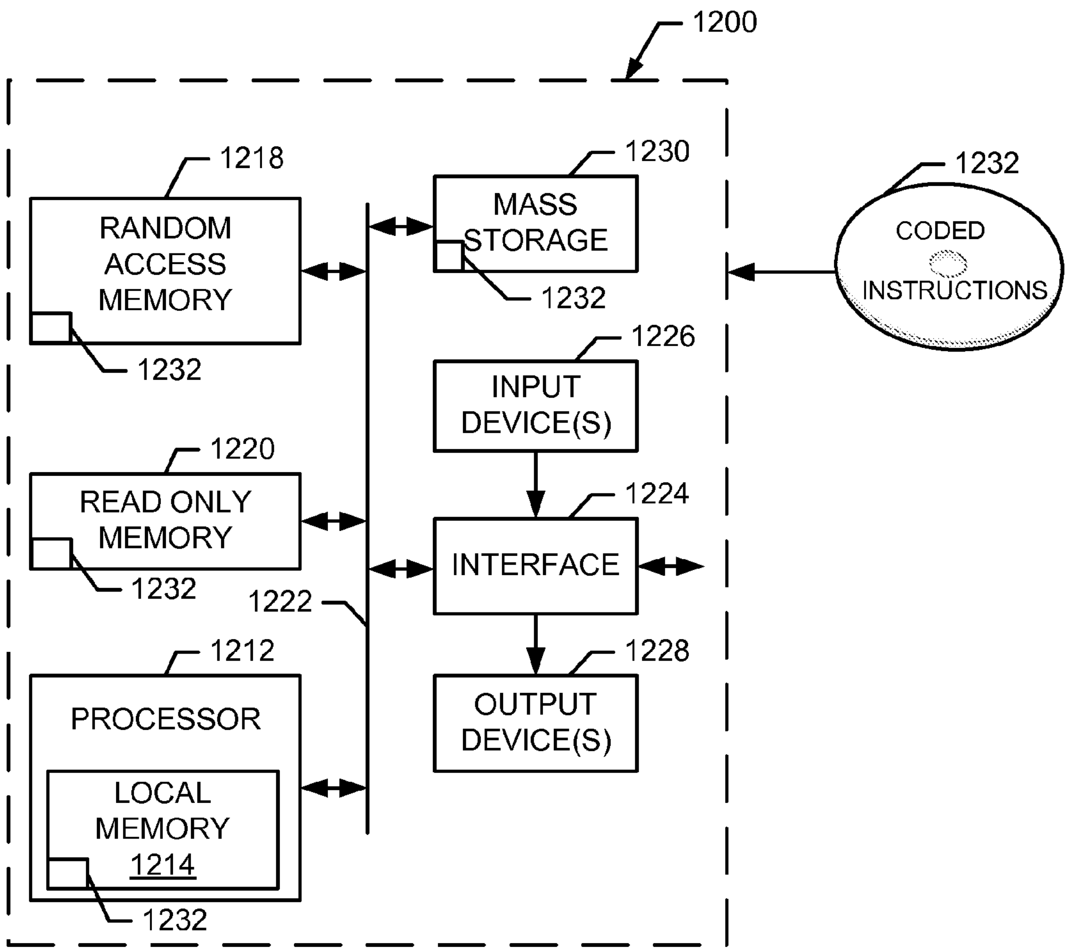
1200
1218
RANDOM ACCESS MEMORY
1232
1230
MASS STORAGE
1232
1232
CODED INSTRUCTIONS
1226
INPUT DEVICE(S)
1220
READ ONLY MEMORY
1232
1224
INTERFACE
1222
1212
PROCESSOR
LOCAL MEMORY 1214
1232
1228
OUTPUT DEVICE(S)

FIG. 12

METHODS AND APPARATUS TO ESTIMATE DEMOGRAPHY BASED ON AERIAL IMAGES

FIELD OF THE DISCLOSURE

This disclosure relates generally to surveying and, more particularly, to methods and apparatus to estimate demography based on aerial images.

BACKGROUND

Manufacturers of goods sometimes wish to determine where new markets are emerging and/or developing. Smaller, growing markets are often desirable targets for such studies. As these markets grow larger and/or mature, previous market research becomes obsolete and may be updated and/or performed again.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an example system to estimate demography based on aerial images.

FIG. **2** illustrates an example aerial image of a first example geographic area in which the system of FIG. **1** may detect a relatively high amount of green space.

FIG. **3** illustrates an example aerial image of a second example geographic area in which the system of FIG. **1** may detect a relatively higher building density than the first geographic area of FIG. **2**.

FIG. **4** illustrates an example aerial image of a third example geographic area in which the system of FIG. **1** may detect a number of swimming pools.

FIG. **5** illustrates an example aerial image of a fourth example geographic area in which the system of FIG. **1** may detect buildings having a first roof type.

FIG. **6** illustrates an example aerial image of a fifth example geographic area **600** in which the system of FIG. **1** may analyze traffic information.

FIG. **7** is a flowchart representative of example machine readable instructions which, when executed, cause a processor to implement the example system of FIG. **1** to estimate a demography of a geographic area of interest.

FIGS. **8**A and **8**B collectively illustrate a flowchart representative of example machine readable instructions which, when executed, cause a processor to implement the example object classifier of FIG. **1** to classify an object detected in an aerial image.

FIG. **9** is a flowchart representative of example machine readable instructions which, when executed, cause a processor to implement the example demography database of FIG. **1** to identify geographic areas similar to the geographic area of interest.

FIG. **10** is a flowchart representative of example machine readable instructions which, when executed, cause a processor to implement the example search analyzer, the example search traffic collector, and/or the example search library to analyze search information to estimate demographic characteristic(s) of a geographic area.

FIG. **11** is a flowchart representative of example machine readable instructions which, when executed, cause a processor to implement the example driving traffic analyzer and/or the example driving traffic collector of FIG. **1** to analyze driving information to estimate demographic characteristic(s) of a geographic area.

FIG. **12** is a block diagram of an example processor platform capable of executing the instructions of FIGS. **7**, **8**A, **8**B, **9**, **10**, and/or **11** to implement the system of FIG. **1**.

The figures are not to scale. Wherever possible, the same reference numbers will be used throughout the drawing(s) and accompanying written description to refer to the same or like parts.

DETAILED DESCRIPTION

Traditional methods for determining demography (e.g., household income, population density, population age, family size, etc.) of a geographic area of interest employ human surveyors. Such traditional methods suffer from many shortcomings including high costs, low temporal resolution, and/or an inability to determine demography in many areas due to dangerous conditions and/or geopolitical factors. Determining or estimating demography using known methods is sometimes impracticable or impossible in the dynamic economies of the developing world. Example methods and apparatus disclosed herein employ aerial images and data derived from actual knowledge of geographic areas ("ground truth data," such as from manually sampling an area) to inform estimates of areas that are not sampled directly by human surveyors. Example methods and apparatus disclosed herein reduce costs associated with determining demography using known methods and provide a means to estimate demographics in areas that are difficult to sample with human surveyors and/or cannot be sampled directly.

Example methods and apparatus disclosed herein enable improved estimates of demography in locations where human sampling was previously impracticable. For example, some locations may previously have required the assumption of excessive human and/or monetary risk to obtain uncertain demography information. Some example methods and apparatus disclosed herein may decrease the uncertainty of obtaining demography information and/or decrease the monetary and/or human time investments required to obtain the demography information, thereby lowering risk and increasing the practicability of performing sampling.

Example methods and apparatus disclosed herein obtain an aerial image of a geographic area for which demography is to be estimated and analyzes the aerial image to detect objects. Some such example methods and apparatus classify the objects and/or the aerial image as a whole to determine whether the objects are representative of objects or features associated with types of demographic characteristics. For example, areas indicating a higher average household income may include a number of swimming pools, have roofs of buildings that are a certain color (e.g., copper-colored in some areas, may be any color for a given area), and/or substantial green or open/undeveloped space (e.g., space on which buildings are not present, but may not necessarily be green in color). In some examples, average household income may be estimated based on distance(s) from the geographic area to a landmark or other reference location, based on the characteristics of local transportation resources (e.g., widths of nearby roadways, distance to nearby public transportation systems, etc.), and/or based on a density of buildings in the geographic area.

Example methods and apparatus disclosed herein determine whether objects are representative of demographic characteristics by comparing the aerial image of the geographic area of interest to aerial image(s) of other geographic areas for which ground truth data has been obtained (e.g., ground truth data corresponding to areas that have been manually sampled or surveyed). Based on the comparison, example methods and apparatus estimate the demography of the geographic area of interest. Example methods and apparatus identify similar geographic areas by generating a signature of the geographic area of interest and comparing the signature to reference signatures of aerial images of the geographic areas for which ground truth data has been obtained. In some examples, the signature is generated via a hash, such as a perceptual hash. In some examples, the hash may be modified to focus on the presence and/or absence of identified objects.

Example methods and apparatus disclosed herein combine aerial image-based demography estimation with search information and/or driving traffic information to more accurately estimate demography of a geographic area of interest. In some examples, searches (e.g., Internet searches through web portals such as Google or Bing) that originate from a geographic area of interest are analyzed to determine whether the topics being searched are indicative of demography. For example, the types and/or quantities of search topics in a geographic area of interest may indicate a demographic characteristic and a relevant prevalence of the characteristic in the geographic area. For example, searches pertaining to items used by children may indicate the presence of people of child-rearing ages, and the quantities of such searches indicate a number of persons of that age in the geographic area.

Example methods and apparatus disclosed herein may further collect driving traffic information (e.g., cars, buses, trucks, etc.) and determine demography and/or demography changes based on the driving traffic information. For example, higher traffic in particular areas may indicate a higher number of cars (or other vehicles) being present in a particular area or passing through the area from another area. A higher number of vehicles (e.g., cars, trucks, motorcycles, etc.) may indicate, for example, a higher relative income level.

FIG. **1** is a block diagram of an example system **100** constructed in accordance with the teachings of this disclosure to estimate demography based on aerial images. The example system **100** of FIG. **1** includes an object detector **102**, an object classifier **104**, a density calculator **106**, and a demography estimator **108**. The example system **100** of FIG. **1** uses aerial images of a geographic area of interest **110** (e.g., an area for which the demography is to be estimated), aerial images of other geographic areas, and sampling or ground truth data of the other geographic areas to estimate the demography of the geographic area of interest **110**.

The example system **100** of FIG. **1** further includes an aerial image repository **112** that provides image(s) of the specified geographic area of interest **110** to a requester (e.g., via a network **114** such as the Internet). The example images may include aerially-generated images (e.g., images captured from an aircraft) and/or satellite-generated images. The images may have any of multiple sizes and/or resolutions (e.g., images captured from various heights over the geographic areas). Example satellite and/or aerial image repositories that may be employed to implement the example aerial image repository **112** of FIG. **1** are available from DigitalGlobe®, GeoEye®, RapidEye, Spot Image®, and/or the U.S. National Aerial Photography Program (NAPP). The example aerial image repository **112** of the illustrated example may additionally or alternatively include geographic data such as digital map representations, source(s) of population information, building and/or other man-made object information, and/or external source(s) for parks, road classification, bodies of water, etc.

The example system **100** of FIG. **1** further includes an example demography database **116**. The example demography database **116** of FIG. **1** stores information about the demographies of geographic areas. The demographic information stored in the demography database **116** of the illustrated example includes government and/or private census data, survey and/or sampling data, geographic data, and/or any other type of demography information. The example demography database **116** of FIG. **1** stores the demographic information in association with geographic information (e.g., global positioning system (GPS) coordinates) corresponding to the demographic information. The example demography database **116** of FIG. **1** may further store a count and/or estimation of objects detectable in the aerial image of the geographic locations for which demographic information is known.

The example demography database **116** of FIG. **1** responds to a request for demographic information for an area defined by coordinates by returning the requested demographic information. In some examples, the demography database **116** scales, extrapolates, and/or otherwise adjusts demographic information for requested areas that do not precisely correspond to the geographic information stored in the demography database **116**.

The example object detector **102** of FIG. **1** obtains (e.g., requests and receives, accesses from storage, etc.) an aerial image of the geographic area of interest **110** from the aerial image repository (e.g., via the network **114**). Using the aerial image, the example object detector **102** detects objects in the geographic area. The example object detector **102** of FIG. **1** may use color analysis, edge detection, and/or any other suitable automatic image analysis technique and/or object definitions to identify objects. Example objects include roofs, green spaces, swimming pools, landmarks, and/or roadways. The example object detector **102** of the illustrated example further detects characteristics of the example geographic area based on the aerial image. For example, the object detector **102** of the illustrated example determines a distance from the geographic area (e.g., a particular position in the geographic area) to a landmark or other reference location, which may or may not be within the aerial image.

The example object classifier **104** of FIG. **1** classifies the objects detected by the object detector **102**. The object classifier **104** of the illustrate example classifies objects by analyzing locations in the aerial image corresponding to the objects detected by the object detector **102**. Example objects that may be detected by the object classifier **104** include swimming pools, structure roofs of a designated type, green spaces, landmarks, distances to one or more reference location(s), or a roadway having a width within a designated range. The example object classifier **104** of FIG. **1** further determines a density of buildings in the geographic area based on the aerial image.

To detect whether an object is a swimming pool, the example object classifier **104** of FIG. **1** determines whether the color of the object in the aerial image is within a color range (e.g., dark blue to light blue) and whether the area of the object is less than an upper threshold (e.g., to avoid classifying larger bodies of water as swimming pools). In some examples, the object classifier **104** further determines whether the color of the object is greater than a lower threshold.

To detect whether an object is a green space, the object classifier **104** of the illustrated example determines whether the color of the object corresponds to that of local green space. While some green space may be in the green color range, other green space may be in other color ranges (e.g., a brown or red color range). In some examples, the object classifier **104** determines whether the object is at least a threshold size (e.g., to discount negligible green spaces). In some other examples, the object classifier **104** does not filter green spaces based on size when all green spaces are considered to be representative of demographic characteristics.

To detect whether the object is a roof of a designated color, the object classifier **104** of the illustrated example determines whether the color of the object is within a color range of the roof type of interest. The color of a roof type may be different for different geographic areas and may indicate different income ranges (e.g., lower than average, average, higher than average, etc.). For example, in some areas a copper-colored roof indicates a higher average income, while in other areas a white-colored or black-colored roof may indicate a higher average income. The example color range(s) may include colors based on shadows of the color range(s) of interest. In some examples, the object classifier **104** determines whether the object has one of a number of shapes consistent with that of a building of interest and/or whether the object is less than an upper threshold size to increase the likelihood that the identified object is a roof.

To detect whether the object is a roadway of a particular width, the object classifier **104** of the illustrated example determines a scale of the aerial image to the geographic area (e.g., 50 meters per inch, 1 meter per pixel, etc.). The example object classifier **104** of the illustrated example converts the width of the roadway into actual distance.

The example object detector **102** of FIG. **1** determines a signature of the aerial image (e.g., a portion of the aerial image corresponding to the geographic area of interest **110**). To this end, the example object detector **102** includes a signature generator **118**, which generates the signature of the aerial image. Generating the signature may include cropping or limiting the aerial image to the portion of the aerial image that corresponds to the geographic area of interest **110**. In some examples, the signature generator **118** performs a hash of the aerial image, such as a perceptual hash. In some other examples, the signature generator **118** generates a signature based on the detected and/or classified objects.

The example demography estimator **108** of FIG. **1** receives the classifications (e.g., a swimming pool, a first type of structure roof, a green space, a distance range to a reference location, or a roadway width range) of the objects from the object classifier **104** and a signature of the aerial image from the signature generator **118**. The example demography estimator **108** of FIG. **1** communicates with the demography database **116** to request geographic areas and corresponding demographies of geographic areas that are similar to the geographic area of interest **110** based on the number(s) and/or classification(s) of the objects in the aerial image of the geographic area of interest **110**. For example, the demography estimator **108** may query the demography database **116** using the number(s) and/or classification(s) of the objects in the aerial image and providing a threshold similarity to the objects. The example demography database **116** returns to the demography estimator **108** any geographic areas that are within the threshold similarity to the geographic area of interest **110** based on the numbers and/or classifications of the objects, and the demographies corresponding to the returned geographic areas.

Additionally or alternatively, the example demography estimator **108** of FIG. **1** communicates with the demographic database **116** to request geographic areas and corresponding demographies that are similar to the geographic area of interest **110** based on the signature of the aerial image and based on signatures stored in the example demography database **116**. For example, the demography estimator **108** may query the demography database **116** using the signature of the aerial image as a key and providing a threshold similarity to the signature. The example demography database **116** returns to the demography estimator **108** any geographic areas that are within the threshold similarity to the geographic area of interest **110** based on the signatures, and the demographies corresponding to the returned geographic areas.

Based on the classifications of the objects in the aerial image, the density of objects in the aerial image, and/or the signature of the aerial image, and based on the demographies received from the demography database **116**, the example demography estimator **108** of FIG. **1** estimates the demography of the geographic area of interest. For example, the demography estimator **108** of the illustrated example weights and/or combines the demographies received from the demography database **116** based on relative similarities of the geographic areas returned by the demography database **116** (e.g., determined based on object classifications and/or signatures) to the geographic area of interest **110**. In the example of FIG. **1**, the demography estimator **108** gives higher weights to the demographies of areas that are more similar to the geographic area of interest **110** and lower weights to the demographies of areas that are less similar. The example demography estimator **108** may further weight the demographies of the areas based on relative sizes of the geographic areas to the geographic area of interest **110**.

The example demography estimator **108** of the illustrated example estimates the demography based on the weighted and/or scaled demographies by, for example, averaging the weighted and/or scaled demographies (e.g., root-mean-squared averaging, determining the mean, etc.). The example demography estimator **108** of the illustrated example then outputs the estimated demography and/or stores the estimated demography in the demography database **116** in association with a definition of the geographic area of interest **110**, with a timestamp, with the aerial image of the geographic area of interest **110**, with the signature of the aerial image, and/or with the classifications of the objects in the aerial image.

The example system **100** of FIG. **1** may repeat estimation of the demography of the geographic area of interest **110** at different times (e.g., quarterly, bi-annually, annually, etc.) to monitor the development of the geographic area of interest **110** over time and/or to predict future development. The demography may be used to, for example, identify emerging markets and/or a developing potential for marketing goods and services to an underserved demographic.

The example system **100** of FIG. **1** further includes a search analyzer **120** to determine demography information based on searches (e.g., Internet searches) performed from the geographic area of interest. The example search analyzer **120** includes a search traffic collector **122**. The example search traffic collector **122** of FIG. **1** collects search information occurring from locations (e.g., IP addresses) within the geographic area of interest **110**. For example, the search traffic collector **122** of FIG. **1** receives search information (e.g., search terms for searches performed) from search providers, such as Google, Bing, Yahoo!, and/or any other search or other Internet providers (e.g., Amazon.com, etc.) of interest. To obtain the search information, the search traffic collector **122** determines IP addresses corresponding to the geographic area of interest (e.g., from Internet service providers serving the geographic area of interest), and requests searches corresponding to the IP addresses. In other examples, the entity conducting the study recruits panelists to participate in the study and downloads online meters to the panelists' computers or other Internet access devices to automatically collect data indicative of interests (e.g., URLs, search terms, etc.).

Irrespective of how the data is collected, upon receiving the search information, the example search analyzer **120** of FIG. **1** determines demographic characteristics of the area based on a qualitative analysis of the search topics or terms. For example, the search analyzer **120** may compare the search topics to a search library **124** that correlates search topics to demographic characteristics. The example search analyzer **120** may further determine a number of each type of search or class of search (e.g., searches having particular keyword(s)) to determine a prevalence of demographic characteristics in the geographic area of interest **110**. For example, a higher number of a particular search topic may be indicative of a higher number of persons having a corresponding demographic characteristic in the geographic area of interest **110**.

The example search analyzer **120** of FIG. **1** additionally or alternatively obtains a comparison of demographic characteristics to search topics from the example demography database **116**. The example search analyzer **120** may compare types and/or quantities of search topics from the geographic area of interest **110** to types and/or quantities of search topics stored in the demography database **116**. Based on the comparisons and the demographic characteristics received from the demography database **116** in association with the search topics, the example search analyzer **120** of FIG. **1** determines corresponding estimated demographic characteristics for the geographic area of interest. The example search analyzer **120** and/or the example driving traffic analyzer **126** provide the estimated demography information to the example demography estimator **108**, which combines the search-based demography estimates, traffic-based demography estimates, and/or aerial image-based estimates of demography to determine an overall estimate of demography.

The example driving traffic analyzer **126** of FIG. **1** analyzes driving traffic in the geographic area of interest **110** to estimate demography information. The example driving traffic analyzer **126** includes a driving traffic collector to obtain driving traffic information for the geographic area of interest. Example sources of driving traffic information include publicly available traffic databases such as Google Maps. Example traffic information shows color-coded overlays on a map of a roadway to indicate relative speeds of traffic over the corresponding portion of the roadway. In some examples, the driving traffic collector **128** obtains traffic information for areas outside of the geographic area of interest **110** (e.g., because many persons having an abode within the geographic area of interest **110** may commute or otherwise travel to places outside of the geographic area of interest **110**).

The example traffic analyzer **126** of FIG. **1** analyzes the traffic information (e.g., interprets the color-coded overlay) and converts the traffic information to a number of cars (and/or other vehicles such as trucks and/or motorcycles, etc.) associated with the example geographic area of interest. The example traffic analyzer **126** further identifies flows of traffic (e.g., based on times of day) to identify the sources of the traffic and/or a proportion of the traffic that originates in the geographic area of interest. The example traffic analyzer **126** combines the traffic originating in the geographic area of interest **110** with traffic arriving at a destination (e.g., a downtown area, an industrial area, etc.) and characteristics of persons associated with the destinations (e.g., higher income, lower income, etc.) to estimate one or more characteristics of the geographic area of interest **110**. Similarly, the example traffic analyzer **126** may determine an amount of traffic terminating in the geographic area of interest **110** to determine, for example, a level of commercial, retail, and/or industrial activity occurring within the geographic area of interest **110**.

The example driving traffic analyzer **126** provides the driving traffic information to the example demography estimator **108**. The example demography estimator **108** considers the traffic information when estimating the demography of the example geographic area of interest **110**.

In some examples, the driving traffic analyzer **126** analyzes the aerial image of the geographic area of interest **110** to identify one or more parking lots (e.g., a space having a black or other color and having a number of car-type objects) and/or roadside parking areas (e.g., spaces having a number of car-type objects in a line adjacent a roadway). The example driving traffic analyzer **126** may combine the traffic information (e.g., originating and/or terminating traffic information) with the parking lot data to further estimate the number of cars in the geographic area of interest **110**.

FIG. **2** illustrates an example aerial image **200** of a first example geographic area **202** in which the system **100** of FIG. **1** may detect a relatively high amount of green space. The image **200** of FIG. **2** may be processed by the example object detector **102**, the example object classifier **104**, the example density calculator **106**, and/or the example signature generator **118** of FIG. **1**.

As illustrated in FIG. **2**, the example geographic area **202** includes multiple buildings **204** generally intermixed with green space **206** (illustrated by cross-hatching in FIG. **2**). The example object detector **102** of FIG. **1** may detect the buildings **204** and the green space **206** based on, for example, the shapes of the buildings **204** and the color of the aerial image representing the green space **206**. The example object classifier **104** of FIG. **1** classifies the example buildings **204** and/or determines whether the buildings have a particular color of roof. The example density calculator **106** of FIG. **1** calculates a density of the buildings **204** (e.g., a number of buildings **204** and/or an area occupied by the buildings per unit area) and/or calculates a density of the green space **206** (e.g., a number of distinct green spaces separated by non-green spaces and/or an amount of green space per unit area).

FIG. **3** illustrates an example aerial image **300** of a second example geographic area **302** in which the system of FIG. **1** may detect a relatively higher building density than the first geographic area **202** of FIG. **2**. The example geographic area **302** of FIG. **3** includes a number of buildings **304**. The example density calculator **106** of FIG. **1** may calculate the density of the buildings **304** in the geographic area **302**, which is higher than the density of the buildings **204** in the example geographic area **202** of FIG. **2**. The density may be based on a number of objects detected and/or based on an area occupied by the objects relative to the size of the geographic area **202**.

FIG. **4** illustrates an example aerial image **400** of a third example geographic area **402** in which the example system **100** of FIG. **1** may detect a number of swimming pools **404**. The example object detector **102** and the example object classifier **104** of FIG. **1** may identify and classify the swimming pools **404** based on the color of the aerial image in the locations of the swimming pools **404** and the sizes of the swimming pools **404**. The example object classifier **104** of FIG. **1** classifies the swimming pool **404***a* as a swimming pool (e.g., as a public swimming pool) based on the size (e.g., a size falling between lower and upper thresholds), but does not classify a body of water **406** as a swimming pool due to the size of the body of water **406** (e.g., the water **406** has a size greater than the upper threshold). While example swimming pools **404** and bodies of water **406** are illustrated in FIG. **4**, the threshold size between a body of water and a swimming pool may be different than an example threshold used by the example object classifier **104** of FIG. **1** to distinguish the example swimming pools **404** and the example bodies of water **406** of FIG. **4**. For example, private and/or public swimming pools may be sized differently in different geographic areas. The example object classifier **104** of FIG. **1** may further determine whether objects are swimming pools based on the presence and/or absence of straight lines. For example, larger public swimming pools may be defined by one or more straight lines. However, shorelines of large bodies of water may also appear to be a straight line. Accordingly, the example object classifier **104** of FIG. **1** performs the classification of swimming pools based on a combination of straight lines, shapes (e.g., kidney shaped pools), and/or sizes.

FIG. **5** illustrates an example aerial image **500** of a fourth example geographic area in which the system of FIG. **1** may detect buildings **502** having a first roof type. The example object classifier **104** of FIG. **1** classifies the example buildings **504** by determining a color of the buildings **504** and comparing the color to a color range. The example object classifier **104** may further compare a size of the buildings **504** to an upper threshold and/or to a lower threshold. In some examples, the object classifier **104** determines whether the shape of the buildings **504** are typical of buildings of interest (e.g., square, rectangular, and/or polygonal objects are consistent with housing units, while circular, oval, or irregularly shaped objects are not consistent with housing units in some areas).

FIG. **6** illustrates an example aerial image of a fifth example geographic area **600** in which the system of FIG. **1** may analyze traffic information. The example aerial image of FIG. **6** includes an overlay on which different traffic speeds are illustrated. A first illustrated traffic indicator **602** illustrates that a first driving traffic flow along a first path is traveling at a first (e.g., faster) speed range. A second illustrated traffic indicator **604** illustrates that a second driving traffic flow along the first path, in the opposite direction, is traveling at a second (e.g., slower speed range). The example traffic analyzer **126** of FIG. **1** may analyze the traffic indicators **602**, **604**, the beginning and ending points of the traffic indicators **602**, **604**, and/or any indications of parking lots (e.g., a parking lot **606**) to identify that the traffic associated with the indicator **602** originates in the geographic area **600**, and the traffic associated with the indicator **604** terminates in the geographic area **600**.

While an example manner of implementing the system **100** is illustrated in FIG. **1**, one or more of the elements, processes and/or devices illustrated in FIG. **1** may be combined, divided, re-arranged, omitted, eliminated and/or implemented in any other way. Further, the example object detector **102**, the example object classifier **104**, the example density calculator **106**, the example demography estimator **108**, the example aerial image repository **112**, the example demography database **116**, the example signature generator **118** and/or, more generally, the example system **100** of FIG. **1** may be implemented by hardware, software, firmware and/or any combination of hardware, software and/or firmware. Thus, for example, any of the example object detector **102**, the example object classifier **104**, the example density calculator **106**, the example demography estimator **108**, the example aerial image repository **112**, the example demography database **116**, the example signature generator **118** and/or, more generally, the example system **100** could be implemented by one or more analog or digital circuit(s), logic circuits, programmable processor(s), application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)) and/or field programmable logic device(s) (FPLD(s)). When reading any of the apparatus or system claims of this patent to cover a purely software and/or firmware implementation, at least one of the example object detector **102**, the example object classifier **104**, the example density calculator **106**, the example demography estimator **108**, the example aerial image repository **112**, the example demography database **116**, and/or the example signature generator **118** is/are hereby expressly defined to include a tangible computer readable storage device or storage disk such as a memory, a digital versatile disk (DVD), a compact disk (CD), a Blu-ray disk, etc. storing the software and/or firmware. Further still, the example system **100** of FIG. **1** may include one or more elements, processes and/or devices in addition to, or instead of, those illustrated in FIG. **1**, and/or may include more than one of any or all of the illustrated elements, processes and devices.

Flowcharts representative of example machine readable instructions for implementing the system **100** of FIG. **1** are shown in FIGS. **7**, **8**A, **8**B, **9**, **10**, and/or **11**. In this example, the machine readable instructions comprise programs for execution by a processor such as the processor **1212** shown in the example processor platform **1200** discussed below in connection with FIG. **12**. The program may be embodied in software stored on a tangible computer readable storage medium such as a CD-ROM, a floppy disk, a hard drive, a digital versatile disk (DVD), a Blu-ray disk, or a memory associated with the processor **1212**, but the entire program and/or parts thereof could alternatively be executed by a device other than the processor **1212** and/or embodied in firmware or dedicated hardware. Further, although the example programs are described with reference to the flowcharts illustrated in FIGS. **7**, **8**A, **8**B, **9**, **10**, and/or **11**, many other methods of implementing the example system **100** may alternatively be used. For example, the order of execution of the blocks may be changed, and/or some of the blocks described may be changed, eliminated, or combined.

As mentioned above, the example processes of FIGS. **7**, **8**A, **8**B, **9**, **10**, and/or **11** may be implemented using coded instructions (e.g., computer and/or machine readable instructions) stored on a tangible computer readable storage medium such as a hard disk drive, a flash memory, a read-only memory (ROM), a compact disk (CD), a digital versatile disk (DVD), a cache, a random-access memory (RAM) and/or any other storage device or storage disk in which information is stored for any duration (e.g., for extended time periods, permanently, for brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term tangible computer readable storage medium is expressly defined to include any type of computer readable storage device and/or storage disk and to exclude propagating signals. As used herein, "tangible computer readable storage medium" and "tangible machine readable storage medium" are used interchangeably. Additionally or alternatively, the example processes of FIGS. **7**, **8**A, **8**B, **9**, **10**, and/or **11** may be implemented using coded instructions (e.g., computer and/or machine readable instructions) stored on a non-transitory computer and/or machine readable medium such as a hard disk drive, a flash memory, a read-only memory, a compact disk, a digital versatile disk, a cache, a random-access memory and/or any other storage device or storage disk in which information is stored for any duration (e.g., for extended time periods, permanently, for brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable device or disk and to exclude propagating signals. As used herein, when the phrase "at least" is used as the transition term in a preamble of a claim, it is open-ended in the same manner as the term "comprising" is open ended.

FIG. **7** is a flowchart representative of example machine readable instructions **700** which, when executed, cause a processor to implement the example system **100** of FIG. **1** to estimate a demography of a geographic area of interest. The example instructions **700** of FIG. **7** may be executed to implement the example object detector **102**, the example object classifier **104**, the example density calculator **106**, the example density estimator **108**, the example aerial image repository **112**, and the example demography database **116**.

The example object detector **102** obtains (e.g., receives, accesses from storage) an aerial image of a geographic area of interest **110** (block **702**). For example, the object detector **102** may request and receive the aerial image from the example aerial image repository **112** of FIG. **1**. The example object detector **102** and/or the example density calculator **106** of FIG. **1** analyzes the aerial image (e.g., using image analysis techniques) to detect objects and/or determine characteristics of the geographic area (block **704**). For example, the object detector **102** may detect objects and/or determine characteristics based on the aerial image based on shapes, colors, and/or boundaries in the image. Additionally or alternatively, the example density calculator **106** may determine a density of one or more objects in the aerial image.

The example object classifier **104** of FIG. **1** selects a detected object (block **706**) and classifies the selected object (block **708**). For example, the object classifier **104** may determine a type of the object based on characteristics of the object. In some examples, one or more of the objects may not be classified or may be classified as an unknown type if, for example, the object is not classified as one of a set of objects. Example instructions that may be executed to implement block **708** are described below with reference to FIGS. **8**A and **8**B. The object classifier **104** determines whether there are any additional objects to be classified (block **710**). If there are additional objects (block **710**), control returns to block **706** to select another object to be classified.

When the detected objects have been classified and there are no additional objects (block **710**), the example demography estimator **108** identifies geographic area(s) having aerial images similar to the aerial image of the geographic area of interest (block **712**). For example, the demography estimator **108** may request geographic areas and/or aerial images from the example demography database **116** based on a signature generated by the signature generator **118** and/or object classifications determined by the object classifier **104**. Example instructions that may be executed to implement block **712** are illustrated below with reference to FIG. **9**.

The example demography estimator **108** obtains demographic characteristics of the identified geographic region(s) (block **714**). For example, the demography estimator **108** may receive the demographic characteristics (e.g., population, household income, household population, ages, genders, etc.) of the geographic areas identified by the demography database **116**.

The demography estimator **108** estimates the demography of the geographic area of interest **110** of FIG. **1** based on the demographic characteristics of the identified geographic area(s) (block **716**). For example, the demography estimator **108** may weight and/or scale the demographic characteristics of the identified geographic areas based on respective similarities between the identified geographic areas and the geographic area of interest **110** (e.g., based on object classifications, numbers, geographic area characteristics such as object density, and/or signatures of the aerial images). The demographic estimator **108** may then average or otherwise combine the demographic characteristics to estimate the demographic characteristics of the geographic area of interest **110**. In some examples, the example demography estimator **108** estimates the demography of the geographic area of interest **110** by imputing demographic characteristics of a second geographic area stored in the demography database **116** to the example geographic area of interest **110** based on similarity between respective signatures and/or object classifications. The example instructions **700** of FIG. **7** may then end.

FIGS. **8**A and **8**B show a flowchart representative of example machine readable instructions **800** which, when executed, cause a processor to implement the example object classifier **104** of FIG. **1** to classify an object detected in an aerial image. The example instructions **800** of FIGS. **8**A and **7**B may be executed to implement block **708** of FIG. **7** to classify a selected object. The example instructions **800** are described below with reference to a selected object (block **706** of FIG. **7**).

Referring to FIG. **8**A, the example object classifier **104** determines whether a color of the selected object is equal to a roof color of interest (e.g., determined based on color values such as Red-Green-Blue (RGB) encoded values) (block **802**), whether the object area is within a size range (e.g., less than an upper threshold and/or greater than a lower threshold) (block **804**), and whether the selected object has a shape consistent with that of a building of interest (e.g., a house) (block **806**). The example roof color of interest may be a color range and/or may consider the effects of shadows in the aerial image. The example roof size range may be selected to represent adequate building sizes to represent the building of interest (e.g., houses, apartment buildings, etc.). The acceptable shape(s) may be selected to filter natural objects (e.g., objects not having straight lines) or other building shapes. If the color of the selected object is a roof color of interest (block **802**), the selected object area is within a roof size range (block **804**), and the selected object has a shape consistent with that of a building of interest (block **806**), the example object classifier **104** classifies the object as a roof of a first type.

If the object classifier **104** determines that the color of the selected object is not a roof color of interest (block **802**), that the selected object area is too large or too small (block **804**), or that the selected object has an irregular shape (block **806**), the example object classifier **104** determines whether the object color is within one or more water color range(s) (block **810**) whether the object area is within a swimming pool size range (block **812**). The water color range(s) may be selected based on the effects of different substances beneath the swimming pool water, the potential depths of the water, the effects of shadows, unfilled swimming pools, and/or other considerations that may affect the observed color of swimming pools. The swimming pool size range may be selected based on observed ranges of private and public swimming pools. If the selected object color is within a water color range (block **810**), and the selected object area is within a swimming pool size range (block **812**), the example object classifier **104** classifies the selected object as a swimming pool (block **814**). In some examples, classification of a swimming pool may be based on the presence of straight lines in the object and/or based on a shape of the object.

Referring to FIG. **8**B, if the selected object color is outside of the water color range(s) (block **810**), or the selected object area is not within a swimming pool size range (e.g., the object is too small or too large) (block **812**), the example object classifier **104** determines whether the distance from the selected object to the reference object is less than a threshold (block **816**). If the distance is less than a threshold (block **818**), the example object classifier **104** classifies the selected object as near reference object (block **818**). The example selected object may be an object selected by the object detector **102** to determine the distance from the geographic area of interest **110** to the reference object. The example reference object may be a point of interest and/or a landmark, or any other reference object for which a distance from the object is indicative of at least one demographic characteristic of an area. In some examples, the object classifier **104** executes blocks **816** and **818** in addition to classifying an object as another type of object (e.g., a swimming pool, a roof, a green space, a landmark, etc.).

If the distance is at least a threshold distance (block **816**), the example object classifier determines whether a color of the selected object is within a green space color range (block **820**) and whether the object area is greater than a size threshold (block **822**). The green space color range may be selected to be representative of green spaces (e.g., parks, developed natural areas, green spaces on personal property such as front yards and/or back yards, etc.) for the geographic area of interest. For example, a first geographic region may have different terrain than a second geographic region, necessitating different vegetation and/or other considerations for local green spaces in the respective regions. The threshold object size for green spaces may be a lower threshold to avoid counting negligible green spaces and/or other non-green space objects that may not be representative of demographic characteristics. If the color of the selected object is within the green space color range (block **820**) and the object area in greater than the threshold (block **822**), the example object classifier **104** classifies the object as a green space (block **824**).

After classifying the object (blocks **808**, **814**, **818**, or **824**), or if the object is not classified (blocks **820**, **822**), the example instructions **800** of FIG. **8**B return the classification or lack of classification of the selected object and return control to block **710** of FIG. **7**.

FIG. **9** is a flowchart representative of example machine readable instructions **900** which, when executed, cause a processor to implement the example system of FIG. **1** to identify geographic areas similar to the geographic area of interest **110**. The example instructions **900** of FIG. **9** may be executed by the example demography database **116** of FIG. **1** to implement block **712** of FIG. **7** to identify geographic area(s) having aerial images similar to the aerial image of a geographic area of interest.

The example demography database **116** obtains (e.g., receives, accesses from storage, etc.) a first signature of an aerial image of the geographic area of interest **110** (block **902**). For example, the demography estimator **108** may receive the example signature (e.g., a hash) from the signature generator **118** and/or from the example demography estimator **108** of FIG. **1**.

The example demography database **116** searches a signature library for aerial image(s) having a signature similar to the first signature (block **904**). For example, the demography estimator **108** may query the demography database **116** using the signature of the first aerial image. The example demography database **116** returns similar aerial image(s) based on the signature and signature(s) of the aerial images stored in the demography database **116**. In some examples, the search or query is constrained based on a geographic region of which the geographic area of interest is a portion, based on a threshold similarity (or difference), and/or based on areas for which the demography database **116** has associated demographic information stored.

The example demography database **116** determines geographic area(s) corresponding to the identified aerial image(s) (block **906**). For example, when the demography database **116** has identified similar aerial images (block **906**), the example demography database **116** determines the geographic locations corresponding to the aerial images (block **906**). In some examples, the aerial images are mapped to the geographic areas in the demography database **116**. The example instructions **900** may then end, return the selected geographic areas to the demography estimator **108**, and return control to block **714** of FIG. **7**.

FIG. **10** is a flowchart representative of example machine readable instructions **1000** which, when executed, cause a processor to implement the example search analyzer **120**, the example search traffic collector **122**, and/or the example search library **124** to analyze search information to estimate demographic characteristic(s) of a geographic area.

The example search traffic collector **122** of FIG. **1** obtains (e.g., receives, accesses from storage, etc.) search traffic originating from a geographic area of interest (block **1002**). For example, the search traffic collector **122** of FIG. **1** receives search information from search providers, such as Google, Bing, Yahoo!, and any other search providers of interest. To obtain the search information, the search traffic collector **122** determines IP addresses corresponding to the geographic area of interest (e.g., from Internet service providers serving the geographic area of interest), and requests searches corresponding to the IP addresses.

The example search analyzer **120** of FIG. **1** identifies search terms from the search traffic (block **1004**). For example, the search analyzer **120** may group searches by keywords. The example search analyzer **120** compares search terms to search terms in the example search library **124** to determine demographic characteristics from the search terms (block **1006**). The example search analyzer **120** determines a prevalence of demographic characteristics based on an amount of search term or types of search term used (block **1008**). For example, the example search analyzer **120** may determine a number of each type of search or class of search (e.g., searches having particular keyword(s)) to determine a prevalence of demographic characteristics in the geographic area of interest **110**. A higher number of a particular search topic may be indicative of a higher number of persons having a corresponding demographic characteristic in the geographic area of interest **110**.

The example instructions **1000** of FIG. **10** then end. The example search analyzer **120** of FIG. **1** may provide the estimated demography information determined from the search information to the demography estimator **108** of FIG. **1** to be combined with information from aerial images.

FIG. **11** is a flowchart representative of example machine readable instructions **1100** which, when executed, cause a processor to implement the example driving traffic analyzer **126** and/or the example driving traffic collector **128** of FIG. **1** to analyze driving information to estimate demographic characteristic(s) of a geographic area.

The example driving traffic collector **128** of FIG. **1** obtains driving traffic information (block **1102**). Example sources of driving traffic information include publicly available traffic databases such as Google Maps. The example driving traffic analyzer **126** selects a traffic indicator (e.g., the traffic indicators **602**, **604** of FIG. **6**) (block **1104**). The example driving traffic analyzer **126** determines a starting point, an ending point, and a speed of the flow of the selected traffic indicator (block **1106**). For example, a traffic indicator **602**, **604** may include one or more routes, one or more traffic speed indicators, and/or any other identifiers. The starting and ending points of the traffic indicator **602**, **604** may include changes in traffic speed and/or changes in roadways, for example.

The example driving traffic analyzer **126** determines a number of vehicles originating and/or terminating in the geographic area of interest **110** based on the selected traffic indicator (block **1108**). For example, the traffic analyzer **126** may calculate a number of vehicles that enter or exit between adjoining traffic indicators **602**, **604** to estimate a number of vehicles that have originated from a region around the point where the adjoining traffic indicators **602**, **604** are joined. The example driving traffic analyzer **126** and/or the demography estimator **108** estimates demography based on the number of vehicles (block **1110**). For example, the driving traffic analyzer **126** may provide the vehicle information for vehicles originating and/or terminating in the geographic region of interest **110** to the example demography estimator **108**, which takes the vehicle information into account when estimating demography.

The example driving traffic analyzer **126** determines whether there are additional traffic indicators to be analyzed (block **1112**). If there are additional traffic indicators **602**, **604** to be analyzed (block **1112**), control returns to block **1104** to select another traffic indicator **602**, **604**. If there are no additional traffic indicators **602**, **604** to be analyzed (block **1112**), the example instructions **1100** of FIG. **11** end.

FIG. **12** is a block diagram of an example processor platform **1200** capable of executing the instructions of FIGS. **7**, **8**A, **8**B, **9**, **10**, and/or **11** to implement the system **100** of FIG. **1**. The processor platform **1200** can be, for example, a server, a personal computer, a mobile device (e.g., a cell phone, a smart phone, a tablet such as an iPad™, or any other type of computing device.

The processor platform **1200** of the illustrated example includes a processor **1212**. The processor **1212** of the illustrated example is hardware. For example, the processor **1212** can be implemented by one or more integrated circuits, logic circuits, microprocessors or controllers from any desired family or manufacturer.

The processor **1212** of the illustrated example includes a local memory **1213** (e.g., a cache). The processor **1212** of the illustrated example is in communication with a main memory including a volatile memory **1214** and a non-volatile memory **1216** via a bus **1218**. The volatile memory **1214** may be implemented by Synchronous Dynamic Random Access Memory (SDRAM), Dynamic Random Access Memory (DRAM), RAMBUS Dynamic Random Access Memory (RDRAM) and/or any other type of random access memory device. The non-volatile memory **1216** may be implemented by flash memory and/or any other desired type of memory device. Access to the main memory **1214**, **1216** is controlled by a memory controller.

The processor platform **1200** of the illustrated example also includes an interface circuit **1220**. The interface circuit **1220** may be implemented by any type of interface standard, such as an Ethernet interface, a universal serial bus (USB), and/or a PCI express interface.

In the illustrated example, one or more input devices **1222** are connected to the interface circuit **1220**. The input device(s) **1222** permit(s) a user to enter data and commands into the processor **1212**. The input device(s) can be implemented by, for example, an audio sensor, a microphone, a camera (still or video), a keyboard, a button, a mouse, a touchscreen, a track-pad, a trackball, isopoint and/or a voice recognition system.

One or more output devices **1224** are also connected to the interface circuit **1220** of the illustrated example. The output devices **1224** can be implemented, for example, by display devices (e.g., a light emitting diode (LED), an organic light emitting diode (OLED), a liquid crystal display, a cathode ray tube display (CRT), a touchscreen, a tactile output device, a light emitting diode (LED), a printer and/or speakers). The interface circuit **1220** of the illustrated example, thus, typically includes a graphics driver card, a graphics driver chip or a graphics driver processor.

The interface circuit **1220** of the illustrated example also includes a communication device such as a transmitter, a receiver, a transceiver, a modem and/or network interface card to facilitate exchange of data with external machines (e.g., computing devices of any kind) via a network **1226** (e.g., an Ethernet connection, a digital subscriber line (DSL), a telephone line, coaxial cable, a cellular telephone system, etc.).

The processor platform **1200** of the illustrated example also includes one or more mass storage devices **1228** for storing software and/or data. Examples of such mass storage devices **1228** include floppy disk drives, hard drive disks, compact disk drives, Blu-ray disk drives, RAID systems, and digital versatile disk (DVD) drives.

The coded instructions **1232** of FIGS. **7**, **8**A, **8**B, **9**, **10**, and/or **11** may be stored in the mass storage device **1228**, in the volatile memory **1214**, in the non-volatile memory **1216**, and/or on a removable tangible computer readable storage medium such as a CD or DVD.

The above-disclosed example methods and apparatus reduce costs associated with determining demography of geographic areas when compared with current methods. Example methods and apparatus may be used to provide estimates of demographies in areas that cannot be sampled directly, and can estimate demography more quickly and less expensively than performing sampling or surveying. The demography estimated by example methods and apparatus disclosed herein may be used to, for example, identify emerging markets and/or a developing potential for marketing goods and services to an underserved demographic.

Although certain example methods, apparatus and articles of manufacture have been disclosed herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus and articles of manufacture fairly falling within the scope of the claims of this patent.

What is claimed is:

1. A method, comprising:

analyzing, using a processor, a first aerial image of a first geographic area to detect a first plurality of objects;

analyzing, using the processor, web search terms for searches performed in the geographic area; and

estimating, using the processor, a demographic characteristic of the first geographic area based on the first plurality of objects and the web search terms.

2. A method as defined in claim **1**, further comprising classifying the first plurality of objects.

3. A method as defined in claim **2**, wherein classifications of the first plurality of objects comprise at least one of a swimming pool, a first type of roof for a structure, a green space, a distance range to a reference location, a landmark, or a roadway width range.

4. A method as defined in claim **1**, further comprising analyzing a second aerial image of a second geographic area to detect a second plurality of objects, wherein the estimating of the demographic characteristic of the first geographic area is based on associating sampled data for the second geographic area to the second plurality of objects and comparing the second plurality of objects to the first plurality of objects.

5. A method as defined in claim **1**, further comprising identifying a second geographic area by comparing a first signature of the first aerial image and a second signature of a second aerial image.

6. A method as defined in claim **5**, wherein estimating the demographic characteristic of the first area comprises inputting ground truth characteristics of the second area to the first area.

7. A method as defined in claim **1**, further comprising determining a density of the first plurality of objects, wherein estimating the demographic characteristic of the first geographic area is based on the density of the first plurality of objects.

8. A method as defined in claim **1**, wherein the demographic characteristic comprises household income, population density, population age, or a family size.

9. A method as defined in comprising:

analyzing, using a processor, a first aerial image of a first geographic area to detect a first plurality of objects;

estimating, using the processor, driving traffic originating and terminating in the geographic area; and

estimating, using the processor, a demographic characteristic of the first geographic area based on the first plurality of objects and the estimate of the driving traffic.

10. An apparatus, comprising:

an object detector to detect a first plurality of objects in a first geographic area by analyzing a first aerial image of the first geographic area;

a search analyzer to analyze web search terms for searches performed in the geographic area; and

a demography estimator to estimate a demographic characteristic of the first geographic area based on the first plurality of objects and the web searches.

11. An apparatus as defined in claim **10**, further comprising an object classifier to classify the first plurality of objects by analyzing features in the first aerial image corresponding to the first plurality of objects.

12. An apparatus as defined in claim **11**, wherein classifications of the first plurality of objects comprise at least two of a swimming pool, a first type of roof for a structure, a green space, a distance range to a reference location, or a roadway width range.

13. An apparatus as defined in claim **10**, wherein the object detector is to analyze a second aerial image of a second geographic area to detect a second plurality of objects, the demography estimator to estimate the demographic characteristic for the first area by associating sampled data for the second geographic area to the second plurality of objects and comparing the second plurality of objects to the first plurality of objects.

14. An apparatus as defined in claim **10**, wherein the object detector comprises a signature generator to generate a first signature of the first aerial image and a second signature of a second aerial image, the second aerial image corresponding to a second geographic area different than the first geographic area, the object detector to identify the second geographic area by comparing a first signature of the first aerial image and a second signature of the second aerial image.

15. An apparatus as defined in claim **10**, further comprising a density calculator to determine a density of the first plurality of objects, the demography estimator to estimate the demographic characteristic of the first geographic area based on the density of the first plurality of objects.

16. An apparatus as defined in claim **10**, wherein the demographic characteristic comprises population income, population density, population age, or a family size.

17. An apparatus comprising:

an object detector to detect a first plurality of objects in a first geographic area by analyzing a first aerial image of the first geographic area;

a driving traffic analyzer to estimate driving traffic originating and terminating in the geographic area; and

a demography estimator to estimate a demographic characteristic of the first geographic area based on the first plurality of objects and the estimate of the driving traffic.

18. A computer readable storage medium comprising computer readable instructions which, when executed, cause a processor to at least:

analyze a first aerial image of a first geographic area to detect a first plurality of objects;

analyze web search terms for searches performed in the geographic area; and

estimate a demographic characteristic of the first geographic area based on the first plurality of objects and the web search terms.

19. A storage medium as defined in claim **18**, wherein the instructions are further to cause the processor to classify the first plurality of objects.

20. A storage medium as defined in claim **19**, wherein classifications of the first plurality of objects comprise at least one of a swimming pool, a first type of roof for a structure, a green space, a distance range to a reference location, a landmark, or a roadway width range.

21. A storage medium as defined in claim **18**, wherein the instructions are further to cause the processor to analyze a second aerial image of a second geographic area to detect a second plurality of objects, wherein the estimating of the demographic characteristic of the first geographic area includes associating sampled data for the second geographic area with the second plurality of objects and comparing the second plurality of objects to the first plurality of objects.

22. A storage medium as defined in claim **18**, wherein the instructions are further to cause the processor to identify a second geographic area by comparing a first signature of the first aerial image and a second signature of a second aerial image.

23. A storage medium as defined in claim **22**, wherein the instructions are further to cause the processor to estimate the demographic characteristic of the first area by imputing ground truth characteristics of the second area to the first area.

24. A storage medium as defined in claim **18**, wherein the instructions are further to cause the processor to determine a density of the first plurality of objects, wherein estimating the demographic characteristic of the first geographic area is based on the density of the first plurality of objects.

25. A computer readable storage medium comprising computer readable instructions which, when executed, cause a processor to at least:

analyze a first aerial image of a first geographic area to detect a first plurality of objects;

estimate driving traffic originating and terminating in the geographic area; and

estimate a demographic characteristic of the first geographic area based on the first plurality of objects and the estimate of the driving traffic.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,082,014 B2
APPLICATION NO. : 13/829625
DATED : July 14, 2015
INVENTOR(S) : Terrazas et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the claims,

Column 17, line 7: delete “as defined in”

Signed and Sealed this
Twelfth Day of January, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office